MTU Aero Engines

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Title: "Process for the Manufacture of Adapted, Fluidic Surfaces"
Applicant: MTU Aero Engines GmbH

In Reply to the Official Action of February 23, 2006:

Attached – as a suggestion of formulation – is a new set of claims with the request that it be made the basis of further examination.

I.
(Original) Disclosure

1. The feature combination of the newly filed Claim 1 was originally disclosed in Claims 1 and 4. In view of their numbering and their references, the Subclaims 2 – 9 correspond to the original Claims 2 and 3, as well as 5 through 10.

II.
Novelty

2. The subject matter of the newly filed Claim 1 – and thus its dependent Claims 2 through 9 – displays novelty with respect to prior art.

3. <u>With respect to US 4,755,952 A (D2) and also US 4,382,215 A (D3)</u>

   The novelty of the newly filed Claim 1 with respect to literature references US 4,755,952 A (D2) and US 4,382,215 A (D3) should be beyond dispute. Regarding this, reference is also made to the fact that these two literature references were mentioned as A-Documents in the Search Report.

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4. Novelty with respect to EP 0 453 391 A (D1)

Likewise, the object of the newly filed Claim 1 is new with respect to D1.

The reason is that the subject matter of the newly filed Claim 1 is different from D1 not only as regards the characterizing portion of the former Claim 4 but also in that, by using the previously generated milling program in a first partial step, material is removed by coarse-milling in the region of the flow inlet edge and/or the flow outlet edge and, in an adjoining additional partial step, the flow inlet edge and/or the flow outlet edge are automatically rounded by fine-milling.

The fact is that D1 merely teaches those skilled in the art in quite general terms that, after measuring, a rotating cutting tool used for machining is applied (D1, column 9, lines 40 – 44).

Thus, D1 does in fact not speak of the removal of material by coarse-milling during a first partial step in the region of the flow inlet edge and/or the flow outlet edge and of automatically rounding the flow inlet edge and/or the flow outlet edge by fine-milling during an adjoining second partial step.

Quite on the contrary, D1 rather infers that the addressed cutting tool is a full-form cutting tool as shown by Figure 7 of D1 (D1, column 9, lines 40 – 46).

This Figure 7 of D1 clearly shows that, in conjunction therewith, a full-form cutting tool is to be understood to mean that the contour of the cutting edge of the cutting tool is to be identical to the final contour to be produced.

Referring to this, it is obvious that D1 does not provide a coarse-milling and, directly following this, a fine-milling, but that, rather, the rounded form is created directly, and thus without previous coarse-milling.

Furthermore, D1 does not disclose anywhere that

> the nominal milling program for the region of the flow inlet edge and/or the flow outlet edge comprises several nominal milling paths, namely one nominal milling path in the region of the suction side, respectively one nominal milling path in the region of the pressure side, and – respectively interposed between these two nominal milling paths – at least one nominal milling path for a transition region between the suction side and the pressure side.

Rather, Figure 7 of D1 makes clear that, in accordance with D1, in fact only (exactly) one nominal milling path is provided, i.e., in fact not several nominal milling paths, one of which being located in the region of the suction side and one in the region of the pressure side, and at least one in between.

Consequently, the subject matter of the present Application displays novelty with respect to D1.

III.
Inventive Step

5. Closest prior art

D1 is viewed as the closest prior art because it – compared with D2 or D3 – appears to display the greatest number of features that correspond to the subject matter of Claim 1 of the present Application.

6. Objective problem

Due to the fact that, in accordance with the invention, first coarse-milling occurs with the use of a milling program and that, subsequently, automatic rounding occurs by fine-milling the flow outlet edge or the flow inlet edge, a particularly accurately formed flow inlet edge or flow outlet edge can be formed with high operational reliability.

The reason is that, referring to the process in accordance with D1, which works with a cutting tool adapted to the curvature of the flow inlet edge or to the flow outlet edge, already a minimal offset or a minimal deviation from the ideal relative position can have the result that (for example) too much material is removed and that grooves or the like are formed.

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Likewise, the complex of features in accordance with the characterizing portion of the previous Claim 4, i.e., the provision of several nominal milling paths – respectively one of which being located in the region of the suction side, one in the region of the pressure side and at least one in between – promotes operational reliability while providing a precisely formed flow inlet edge and/or flow outlet edge and, in addition, offers the option of being able to flexibly use the process, including the adaptation of the milling program, for differently configured rotor blades or flow inlet and flow outlet edges.

Due to the fact that the form of the tool is pre-specified in accordance with D1, the process described there is narrowly restricted to a clearly defined contour of the inlet edge or outlet edge, including its transition to the intermediate region between the flow inlet edge and the flow outlet edge. Considering, above all, an aerodynamically well-formed flow profile, not only the forming of the flow inlet and flow outlet edges is important, but the entire progression of the flow profile and, in particular, also the (stepless) transition between the flow inlet edge or the flow outlet edge and the region located between these edges, are also important.

If the process known from D1 were to be used for different flow profiles, either a plurality of individual cutting tools for machining would have to be made available, or the process could not be applied to various flow profiles, without encountering significant impairment of the aerodynamic contours.

In that case, the various different extremely curved or dimensioned flow inlet or outlet edges cannot be manufactured with the process suggested by D1, without ignoring aerodynamic aspects.

In contrast, in accordance with the invention, the division into coarse-milling with subsequent fine-milling for rounding, on one hand, and the fact that, in combination therewith, various milling paths are run – one of which being located on the suction side and one of which being located on the pressure side, and at least one being located in between – it is possible that, within the framework of coarse-milling – in flexible adaptation to the respectively attempted nominal contour – a coarse, however, relatively good adaptation to the resulting nominal contour is effected, whereby, at the same time, the transitions can already be pre-formed in a proper manner. During the subsequent rounding,

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the inlet edge and the outlet edge can be configured accurately formed and rounded in a manner well-consistent with the nominal contour.

In contrast with the process known from D1, the inventive process can be used to produce differently formed or dimensioned flow inlet edges and/or flow outlet edges, without requiring therefor specifically adapted tools of a gas turbine blade in each case. In accordance with the invention, the adaptation to the respective form and to respective dimensioning of the flow inlet edges and/or the flow outlet edges is automatic within the framework of generating the milling program, in which case the same milling tools are used at all times.

Exactly this is not possible with the design in accordance with D1.

Therefore, the invention is to solve the <u>objective problem</u> of providing a process for the manufacture of adapted, fluidic surfaces on gas turbine blades in the region of the flow inlet edges and/or the flow outlet edges of a gas turbine blade, said process permitting – with minimal manufacturing complexity and, in particular, with a relatively small set of tools, and considering differently contoured flow profiles – in an operationally reliable manner, an accurately formed design of the flow inlet edge and/or the flow outlet edge.

7. <u>No encouragement based on prior art</u>

Those skilled in the art, which used D1 as a starting point, could not take any encouragement from any of the cited references, which, in light of the objective problem, would have lead to the subject matter of the present invention.

Moreover, it is out of the question to speak of a (non-inventive) selection invention.

The reason is that none of the References has disclosed that those skilled in the art should first proceed with coarse-milling and then, for rounding, with fine-milling. A selection invention could be taken into consideration only if the alleged invention had been selected from a known range of concrete <u>values</u> or <u>features</u>.

However, due to lacking appropriate disclosure, this is in fact not the case here.

Furthermore, D1 being the closest prior art, in fact detracts from the invention.

The reason is that D1, like the introductory portion of the description of the invention, addresses the fact that it has already been known to machine blade pans by final manual rounding (D1, column 1, lines 49 – 55).

Now D1, in fact, wishes to avoid this (manual) fine-machining and, for this reason, suggests creating the flow inlet edge by a corresponding measuring system and a cutting tool that exactly represents the form.

Therefore, in accordance with D1, a coarse-machining with a subsequent fine-machining is in fact to be avoided.

The sticking point of D1 consists in fact in that – while avoiding a two-step process – a one-step process is used to form the inlet edge by automatic machining, whereby a tool adapted to the form of the flow inlet edge is used.

In contrast, in accordance with the invention, it is suggested that the formation of the flow inlet edge or the flow outlet edge be automatically performed in a first step of coarse-milling and an adjoining second step of fine-milling for rounding.

Furthermore, this is to be achieved in that various nominal milling paths with different locations are to be run.

Inasmuch as D1 obviously points into a completely different direction, those skilled in the art using D1 as the basis would in fact not have implemented the invention.

Furthermore, one skilled in the art could take appropriate encouragement neither from D2 nor from D3, because neither D2 nor D3 disclose the two-step coarse-milling and fine-milling for rounding, and, in addition, neither D2 nor D3 discloses that the nominal milling program for the region of the flow inlet edge and/or of the region of the flow outlet edge comprises several nominal milling paths, namely, respectively, one nominal milling path in the region of the suction side,

one nominal milling path in the region of the pressure side, and – interposed between these two nominal milling paths – one nominal milling path for the transition region between the suction side and the pressure side.

However, it is in fact this that achieves – and this is not made possible by the design in accordance with D1 – that the flow inlet edge or the flow outlet edge can be manufactured automatically with a highly accurate contour, without requiring a tool that has been individually specifically adapted to the form and to the dimensions of the respective flow inlet edge or flow outlet edge (see in conjunction with this, Fig. 7 of D1).

IV.

8. Consequently, the subject matter of Claim 1 of the present invention – and thus also the subject matter of the corresponding subclaims – displays novelty and inventive step with respect to prior art.

Therefore, we politely ask that the protectability of the present invention be ascertained in the international provisional examination report.

In case, contrary to expectations, the Examining Division should not arrive at the conclusion that the subject matter of the present invention displays novelty and inventive step with respect to prior art, a hearing in accordance with Rule 66.6, PCT, is requested as a precautionary measure.

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Attachment
New set of Claims

(New) Patent Claims

1. Process for the manufacture of adapted, fluidic surfaces on gas turbine blades in the region of a flow inlet edge and/or a flow outlet edge of a gas turbine blade, characterized by the following steps:

(a) generating a nominal milling program for the manufacture of fluidic surfaces in the region of one flow inlet edge and/or one flow outlet edge for an ideal gas turbine blade;

(b) measuring the area of an actual gas turbine blade in the region of one flow inlet edge and/or one flow outlet edge thereof;

(c) generating a milling program adapted to the actual gas turbine blade in order to manufacture fluidic surfaces in the region of the flow inlet edge and/or the flow outlet edge for the actual gas turbine blade, whereby measured values determined in step (b) are used to adapt or change the nominal milling program generated in step (a) to the milling program for the actual gas turbine blade;

(d) manufacturing of the fluidic surfaces on the actual gas turbine blades in the region of the flow inlet edge and/or the flow outlet edge by milling with the use of the milling program generated in step (c), whereby, in a first partial step, coarse-milling, in particular roughing, is used to remove material in the region of the flow inlet edge and/or the flow outlet edge, and whereby, in an adjoining second partial step, fine-milling, in particular planing, is used to automatically round the flow inlet edge and/or the flow outlet edge,

whereby the nominal milling program for the region of the flow inlet edge and/or the region of the flow outlet edge comprises several nominal milling paths, namely, respectively one nominal milling path in the region of the suction side, respectively one nominal milling path in the region of the pressure side, and – interposed between these two nominal milling paths – respectively one nominal milling path for a transition region between the suction side and the pressure side, whereby each of the nominal milling paths comprises several nominal path points.

2. Process in accordance with Claim 1,

characterized in that, referring to step (b), the actual gas turbine blade is measured in such a

manner that, in the region of the flow inlet edge and/or in the region of the flow outlet edge, respectively one series of measuring points is determined on a suction side and on a pressure side of the gas turbine blade, whereby each series of measuring points consists of several measuring points distributed over the height and/or length of the flow inlet edge and/or the flow outlet edge.

3. Process in accordance with Claim 2,
characterized in that,
referring to step (c), for each measuring point, a deviation between the ideal gas turbine blade and the actual gas turbine blade is determined, whereby these deviations are used to change the nominal milling program into the milling program for the actual gas turbine blade.

4. Process in accordance with one or more of the Claims 2 through 3,
characterized in that ,
the, or each, series of measuring points determined in the region of the suction side is used to change the respective nominal milling path in the region of the suction side in such a manner that each nominal path point of the respective nominal milling path having a corresponding measuring point is shifted by the value of deviation between the ideal gas turbine blade and the actual gas turbine blade in the region of the suction side.

5. Process in accordance with Claim 4,
characterized in that,
an interpolation is performed for the nominal path points of the respective nominal milling path for which said points no corresponding measuring point is available.

6. Process in accordance with one or more of the Claims 1 through 5,
characterized in that,
the, or each, series of measuring points determined in the region of the pressure side is used to change the respective nominal milling path in the region of the pressure side in such a manner that each nominal path point of the respective nominal milling path having a corresponding measuring point is shifted by the value of deviation between the ideal gas turbine blade and the actual gas turbine blade in the region of the pressure side.

7, Process in accordance with Claim 6,
characterized in that,
an interpolation is performed for the nominal path points of the respective nominal milling path for which said points no corresponding measuring point is available.

8. Process in accordance with one or more of the Claims 1 through 7,
characterized in that ,
an interpolation is performed for the, or each, nominal milling path located between the respective nominal milling path of the suction side and the respective nominal milling path of the pressure side in order to adapt said paths to the actual gas turbine blade.

9. Process as in one or more of the Claims 5 through 8,
characterized in that,
spline interpolations are performed for the manufacture of fluidic and uniform surfaces in the region of the flow inlet edge and/or the flow outlet edge.